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ABSTRACT

Participation of women is increasing in the industrial workforce and in the traditional male occupational groups. The differences between women and men in physical performances such as strength, stamina, and skill, make mandatory the assessment of work requirements in the occupational environment, especially in view of the workforce trends and legal requirements for equal employment opportunity. Use of a taxonomic system based on fundamental human abilities or capacities provides a basis for such assessments. One such system of nine factor analytically identified physical ability factors (cf. Fleishman, 1964) is proposed with an example of the physical-work requirements. Data are presented from an investigation of the physical-performance requirements of 15 benchmark jobs in a county-level governmental personnel classification system. (Author/CC)

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The Differential Effects of Occupational Environments Upon the Physical Performances of Women and Men

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Running Head: Women and Men

The Differential Effects of Occupational Environments Upon the Physical Performances of Women and Men

Women in the Workforce

The movement towards increasing numbers of women in the workforce has been called by Eli Ginsberg (Chair of the U. S. National Commission for Manpower Policy), "the single most outstanding phenomenon of our century," the cumulative consequences of which "will only be revealed in the twenty first and twenty-second centuries" (Beamer, 1978, p. 29). In the United States, not only are women entering the workforce in greater numbers each year, but also the rate of entry has accelerated far beyond that anticipated. This is shown in the data of Figure 1, which has been adapted from the Bureau of Labor Statistics (1977, p. 63).

The figure shows the annual averages, from 1950 through 1976, of labor force participation rates for men and women, with projected rates for future years up to 1990. During 1920, which is not shown in the figure, only about 20% of all women 16 years and older were in the workforce (Pifer, 1976). Their participation grew

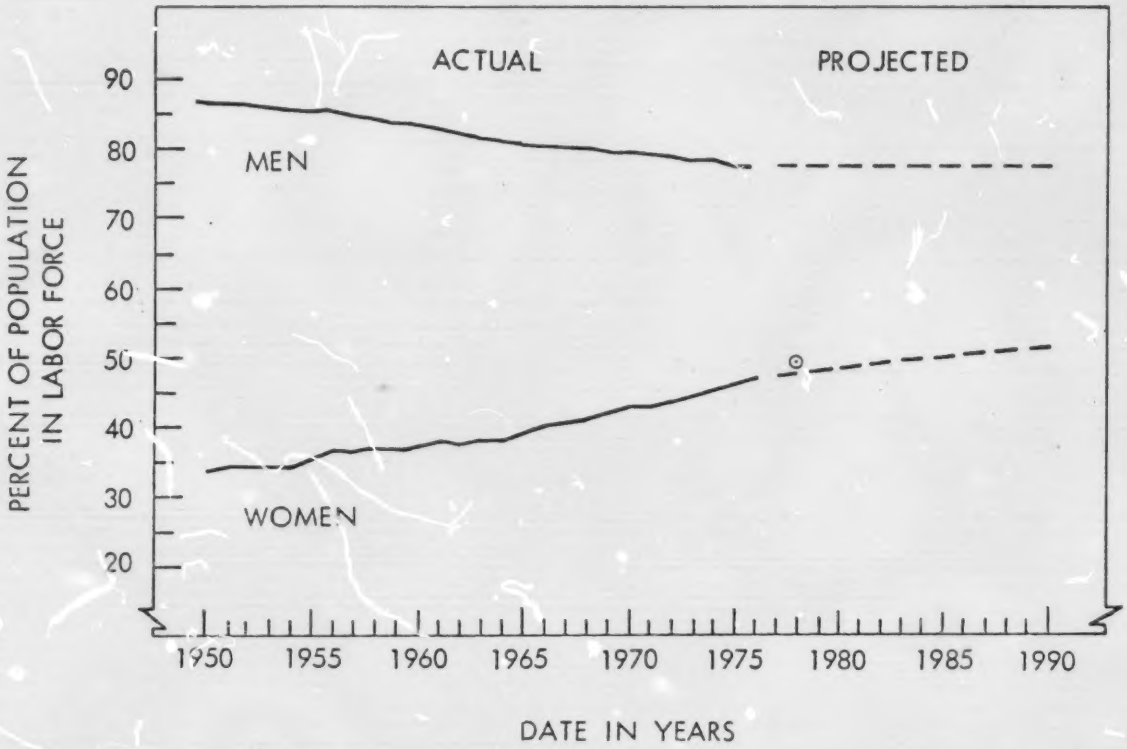

Figure 1. Labor force participation rates of men and women, 1950 through 1976, with projections for 1980, 1985, and 1990 (adapted from Bureau of Labor Statistics, 1977, p. 63). The single circle for 1978 shows the participation rate of women in that year is above the projection line.

to about 34% in 1950 (the first point shown in the figure), and over 47% in 1976 (the last actual data point in the figure). The projected participation rates for women, although just published in 1977, already appear to be too conservative: The projected 1980 participation rate for women of 48.4% was exceeded in 1978 by an actual rate of 49.5% as shown by the open circle in the figure (cf. The Virginian-Pilot, 1978).

Other statistics show similar trends. For example, the life and workforce-life expectancies of men and women at birth are shown for selected years from 1900 to 1970 in Table 1. The data of the last row of the table show that in the United States, women's total worklife expectancy as a percentage of men's has nearly tripled between 1900 and 1970 (Bureau of Labor Statistics, 1977, p. 64). Nor is this trend likely to reverse itself, for it appears that the vast majority of women who work do so out of economic necessity. Specifically, two-thirds of all women in the United States are either single, divorced, widowed, separated, or married to men who earn less than $7000 per year, and the proportion of households headed by women (11%) is increasing (Beamer, 1978).

Women in the American workforce earn on the average only about 60% as much as men, and nearly 70% are employed in just three occupational groups--the clerical, professional/technical, and service groups (Beamer, 1978). Women are seeking higher salaries and status in part by turning to traditionally male-dominated occupations such as transportation equipment work (90% male), malt liquor work (93% male), and airline piloting (where there are now about 50 women among the 33,000 airline pilots in the United States; cf. Satchell, 1978). In the professions, the number of women lawyers, physicians, and dentists more than doubled between 1960 and 1970, and the proportion is still increasing.

Legal Requirements and EEO Goals

Legislative, judicial, and recent executive actions in the United States have mandated that women and men have equal employment opportunity (EEO). In light of the trends indicated above, these legal requirements and EEO goals make necessary the collection of data regarding the physical performances of women and men in occupational environments.

Specifically, in its first EEO-related decision (Griggs v. Duke Power Co.), the U.S. Supreme Court proscribed the use of employment tests that are discriminatory unless the employer could prove job relatedness. That is to say, if a test employed as a selection device for either employment or promotion resulted in lower proportions of minority groups or women hired or promoted, the test or tests could not be used unless the user could demonstrate its validity in predicting job performance. Then, in a second EEO-related decision (Albemarle Paper Co. v. Joseph P. Moody), the Court explained further what would be necessary for that demonstration of valid job relatedness. It said that a test validated on one job could not be used as a selection device for another job, unless by job analysis or other acceptable methods it could be shown that there are no substantial differences between the two jobs. Supervisor ratings could be used as criteria for test validations only where the bases of such ratings could be determined and then shown to be based on carefully defined job-performance criteria representing behaviors actually required by the job. In short, the Court affirmed or reaffirmed that performance based criteria are required for acceptable validation of selection devices.

TABLE 1

LIFE AND WORKFORCE-LIFE EXPECTANCY AT BIRTH IN THE UNITED STATES, WOMEN AND MEN, 1900 TO 1970 (YEARS)

	SELECTED TIMES				
	1900	1940	1950	1960	1970
WOMEN					
LIFE EXPECTANCY	50.7	65.7	71.0	73.1	74.8
WORKFORCE-LIFE EXPECTANCY	6.3	12.1	15.1	20.1	22.9
MEN					
LIFE EXPECTANCY	48.2	61.2	65.5	66.8	67.1
WORKFORCE-LIFE EXPECTANCY	32.1	38.1	41.5	41.1	40.1
WOMEN'S WORKFORCE-LIFE EXPECTANCY AS A PERCENTAGE OF MEN'S	19.6%	31.6%	36.3%	48.6%	57.1%

ADAPTED FROM: BUREAU OF LABOR STATISTICS. U.S. WORKING WOMEN: A DATABOOK (BULLETIN 1977). WASHINGTON, D.C.: U.S. DEPARTMENT OF LABOR, 1977. (TABLE 60, PAGE 64)

The results of the Civil Rights Act of 1964, coupled with judicial decisions regarding that law and the indicated EEO guidelines to be adopted by the executive branch of the U.S. Government[1] can be summarized as follows: (a) If a member of one of the protected classes covered by the law can establish that an employment practice adversely affects the class to which that person belongs, then the legal burden of proof shifts to the employer to demonstrate that the standards used for making the decisions are job related. (b) Presentation by the employer of a rationale, no matter how logical or historically based, is not sufficient to establish the job-relatedness of the practice. Rather, (c) it is necessary for the employer to demonstrate in addition the validity of the practice in terms of job performance, recognizing that supervisor ratings can be used as criteria for such validations only to the extent that they are shown to be based on carefully defined job-performance criteria. Some of the implications of these rulings with regard to the research and development needs for applications to industrial and governmental manpower management systems have been recognized (cf. Alluisi, 1977).

Demands of the Occupational Environment

The assessment of work requirements in the occupational environment is a prerequisite to understanding what the worker must do in performing the job. The dimensions of work variations are numerous; they are also insufficiently defined and complicated by continuous automation and job redesign. The establishment of dimensions, categories, or groupings of job requirements is, in many cases, an arbitrary process originating from practical necessity, rather than from systematic empirical or theoretical rationales. The lack of a comprehensive taxonomic structure for the classification of human work clearly reduces the decisions and predictions of personnel management systems regarding individual workers to lower levels of effectiveness than would be the case were the job demands specifiable in clearer and better terms.

Although numerous job-analysis methodologies exist for describing job tasks and their parameters (cf. Fleishman, 1977; Fleishman & Bass, 1974), the conceptual linkage between task requirements on the one hand, and human performance capabilities on the other, is missing. A great many of the parameters of human performance are known--well-established in the data of a century of experimental psychology research. The evolution of human proficiencies appears to have remained fairly stable over time within any given culture or society, and although the tools and tasks are constantly changing, the manipulation of the tools and the completion of the tasks remain dependent on the capacities of the worker. Successful alterations of the tools or tasks can be accomplished only within the parameters of human performance capabilities. Thus, the dimensions for describing job performances should be based on human performance capabilities, which are relatively constant, rather than on the ever-changing tools and tasks of the job.

This rationale has been used by Fleishman (1975) in his proposal for a system of classifying task requirements in terms of human abilities. There are two inherent advantages to such a taxonomic system: First, the method is parsimonious, in the sense that task requirements are described in terms of a stable set of human capacities. The same set of capabilities underlies the performance

[1]New EEO guidelines have been developed jointly by the Equal Employment Opportunity Commission, the Civil Service Commission, the Department of Labor, and the Department of Justice; adoption is expected during 1978.

requirements of many different tasks, and the performance of a new task can be predicted on the basis of some (possibly different) combination of capabilities drawn from the same single repertoire of human capacities.

Secondly, the use of common dimensions based on human capabilities permits the observations of performances of one task to be related to those of another task (cf. Theologus, Romashko, & Fleishman, 1973). The underlying human-ability dimensions can be used to relate the two different tasks in terms of the demands or requirements placed on the worker, without entrapment in the quagmire of establishing "identity" or "similarity" for the tasks. This permits predictions to be made regarding the effects of specific variables on the performances of different tasks that are known to require the same human capabilities (perhaps, in different degrees) for successful completion (cf. Levine, Kramer, & Levine, 1975; Levine, Romashko, & Fleishman, 1973).

Already identified domains of human abilities might be used as an approach to the delineation of a set of dimensions to describe and classify the performance requirements of tasks. Abilities within the cognitive and perceptual domains have been identified and postulated as constructs underlying a great number of human performances by French, Guilford, and their colleagues (French, 1951; French, Eckstrom, & Price, 1963; Guilford, 1967; Guilford & Hoepfner, 1971), and standardized tests of these abilities have been developed. Similarly, the psycho-motor (Fleishman, 1972) and physical-performance domains (Fleishman, 1964) have also been studied, and specific abilities have been identified as accounting for performances in a wide range of tasks.

Until quite recently, the findings from such research on the nature of human abilities have not been applied in any systematic effort to develop the dimensions needed to describe task requirements. Yet, the development of such a taxonomic system is vitally needed (a) to delineate the relations among tasks, (b) to facilitate generalizations about the effects of independent variables on tasks within given ability categories, and (c) to link requirements of work with the abilities of people.

Abilities: A Basis for Estimating Physical Performance Requirements of Work

For several years, Fleishman and his associates have been involved in the development of a methodology for assessing the physical abilities required for job performances. The method itself is prototypical, in that any specific ability domain (cognitive, perceptual, psychomotor, physical) with adequately defined dimensions can be used to classify tasks in terms of the required abilities. The physical proficiency domain has been examined by means of correlational and factor-analytic paradigms, the results of which serve to organize a great deal of information about the physical performances of tasks (cf. Fleishman, 1964). Substantial efforts have been devoted to the identification of component abilities in physical proficiency, and these efforts have led to the establishment of a set of abilities required in the physical performances of a large variety of physically demanding tasks. With the approach employed, comprehensive coverage as well as orthogonality of the ability categories in the domain are ensured (cf. Fleishman, 1964).

The impetus for this research on the use of abilities as a basis for estimating the physical requirements of work originated in findings that indicated neither a general physical-proficiency factor nor a general strength factor in the performances of physical work (cf. Fleishman, 1962; Fleishman, Kremer, & Shoup, 1961;

Fleishman, Thomas, & Munroe, 1961). A large-scale research project was conducted to investigate actual performances of more than a hundred well-known and diverse physical-proficiency tests (Fleishman, 1964), and nine ability factors were identified as accounting for the predictable variance in the physical performances. The nine factors were identified as follows:

1. Dynamic strength, the ability to exert muscular force repeatedly or continuously over time.

2. Trunk strength, resistance of trunk muscles to fatigue over repeated use.

3. Static strength, the force exerted in lifting, pushing, pulling, or carrying external objects.

4. Explosive strength, the ability to expend a maximum of energy in one or a series of maximum thrusts.

5. Extent flexibility, the ability to extend the trunk, arms, or legs through a range of motion in either the frontal, sagittal, or transverse planes.

6. Dynamic flexibility, the ability to make rapid, repeated flexing movements in which the resilience of the muscles in recovering from distention is critical.

7. Gross body coordination, the ability to coordinate the simultaneous actions of different parts of the body or body limbs while the body is in movement.

8. Gross body equilibrium, the ability to maintain balance in either an unstable position or when forces are pulling.

9. Stamina, or cardiovascular endurance, which enables the performance of prolonged bouts of aerobic work without the experience of fatigue or exhaustion.

These nine factor-analytically identified abilities form the best basis for estimating the physical-performance requirements of work--at least in terms of the currently available alternatives. Rating techniques have been developed to assess the extent to which a job requires each of the nine different abilities, and extensive research has been undertaken to provide for standardization, objectivity, and reliability in the procedure and its product. Proper use of the procedure produces a quantitative profile of the physical abilities judged to be required for successful performance of a given job (cf. Theologus, Romashko, & Fleishman, 1973).

The kinds of data obtainable are illustrated in Figure 2 from a recent investigation of the physical-performance requirements of 15 benchmark jobs in a county-level governmental personnel classification system (Hogan, Ogden, & Fleishman, 1978). The data of the four strength factors are shown; the selection was arbitrary, and the data of the other five factors are comparable.

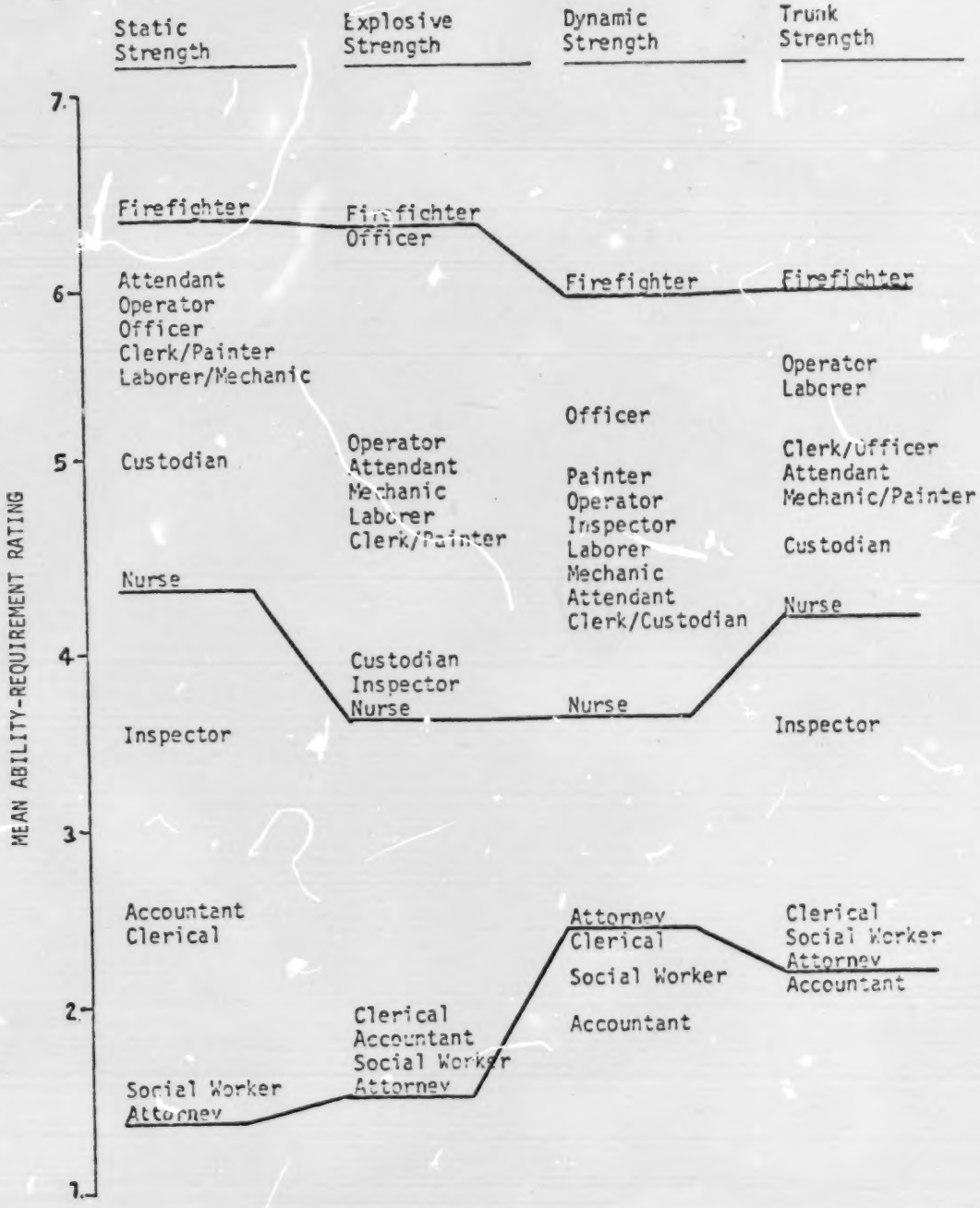

Figure 2. Scaled physical-performance requirements in terms of four factor-analytically identified strength factors for 15 benchmark jobs in a county-level governmental personnel classification system (adapted from Hogan, Ogden, & Fleishman, 1978). Note the job profiling possibilities, as illustrated by way of example with high (firefighter), low (attorney), and intermediate (nurse) strength-requiring jobs.

Quite obviously, the data present, quantitatively, the judged physical-ability requirements of the 15 jobs in terms of the four identified strength factors. The data show, among other things, that the strength requirements of the job of firefighter are high, those for the job of attorney are low, and those for the job of nurse fall at mid-range values. The selection of a person--man or woman--for the job of firefighter should be based on the demonstration by a test of the person that the individual has the abilities--static, explosive, dynamic, and trunk strength --in sufficient degrees to be able to meet the requirements of the job.

Of course, to be optimally useful, a profiling of the physical-performance requirements of a job should include some assessment of the relative importance of the different required abilities. There are many different ways in which such assessments could be made or estimated, but none has been developed to the extent that it can be recommended as "the standard" to be followed by all researchers. In the cited case (Hogan et al., 1978), a statistical decision model was employed for this purpose, and apparently with reasonable success. However, more research is clearly required, and the utility of the basic methodology will be substantially improved when a valid method of assessing the relative importance of the various factors can be recommended. The absence of the importance assessment does not invalidate the methodology which is still useful as a means for profiling the physical-ability requirements of jobs. The potential utility of such profiles should be evident, given the legal requirements and EEO goals as well as the women-in-the-workforce trends discussed previously, especially in view of the gender differences in physical-performance capabilities which are summarized below.

Physical-Performance Capabilities of Women and Men

There have been three major reviews of gender differences during the past decade: Garai and Scheinfeld in 1968, Ounsted and Taylor in 1972, and Maccoby and Jacklin in 1974. All three have focused primarily on the identification of sex differences in primary abilities and traits; only parts of their findings are of major relevance here. For example, several researchers have observed that men appear to perform better on tasks requiring perceptual-motor responses, while women perform better on tasks requiring clerical skills (Garai & Scheinfeld, 1968; Hutt, 1972; Tyler, 1965). McGuinness (1976), on the other hand, suggests that such generalizations obscure the more basic differences between men and women in response and information-processing characteristics.

On the response side, from mid-childhood on, males are superior to females in speed of response (Fairweather & Hutt, 1972; Noble, Baker, & Jones, 1964; Simon, 1967). Females, on the other hand, appear to be superior in manual dexterity involving discrete movements of the fingers and fine coordination (Annett, 1970; Tyler, 1965). These differences in response superiorities are further amplified when paired with apparent differences in the processing of different types of information.

For example, men are overwhelmingly superior to women when the information to be processed is presented via a visual display and the response requires large muscle units (Ammons, Alprin, & Ammons, 1955; Cook & Shephard, 1958; Noble & Hays, 1966; Shephard, Abbey, & Humphries, 1962). Women are decidedly superior when the information to be processed is symbolic or semantic and

the response demands small, reasonably well-coordinated movements and attention to detail (Garai & Scheinfeld, 1968; Tyler, 1965).

With regard to physical-strength characteristics of women and men, the literature has traditionally exhibited asymmetry--there has been much more information regarding males (cf. Hunsicker, 1955; Woodson & Conover, 1970). Recently, however, Montoye and Lamphiear (1977) studied 3200 males and 3300 females from a single community for grip and arm strength. Their report provides extensive comparisons and percentile scores by age (10 to 69 years) and six for grip strength, arm strength, and a strength index (which is the sum of the former two), expressed both in absolute values and as ratios to body weight. In each case, the strength measurements for the two sexes resulted in two non-overlapping distributions, even when the strengths were corrected for body weight. The mean male strength was approximately double that of the female for each measure. When the strengths were adjusted for body weights, the female indices were approximately 60% of those for the males. These results were based on the data of adults only; such magnitudes of differences did not appear until the late teens, but were thereafter relatively constant throughout adulthood.

The effects of relative muscle loading on endurance were studied by Caldwell (1963) with measurements of the manual isometric pulling of 18 men and 18 women who ranged in age from 17 to 21 years. The mean male strength was 155 lbs; the mean female strength was 85 lbs, and there was no overlap between the two strength distributions, with the weakest male 22 lbs stronger than the strongest female in the sample. There was no difference between the males and females in their endurance when this was measured with equal relative loading--i.e., when the load to be maintained was a constant percentage of the subject's maximum strength. This implies that men will be superior to women in endurance when measured with equal absolute loading--i.e., when the load to be maintained is a constant. Indeed, in typical studies of strength and endurance, where a constant load must be supported for as long as possible, the correlation between strength and endurance is moderately high, ranging from +.70 to +.90 (cf. Caldwell, 1961, 1963; McCormick, 1964; Tuttle, Janney, & Thompson, 1950).

With respect to the physiological requirements for prolonged heavy work, one of the factors determining capacity is the available supply of oxygen (Dill, 1933). In fact, the suitability of a person for long, continued heavy work may be inferred from measurements of the individual's capacity for absorbing oxygen (Christensen, 1953). In an extensive study of this physiological requirement, Astrand (1954) thoroughly investigated physical working capacities with respect to both sex and age. Based on the premise that the limiting factor for heavy work is an individual's aerobic capacity (oxygen intake) during prolonged durations of work, and anaerobic capacity (blood lactic acid concentration) during brief durations, Astrand determined the work capacities of 112 females and 115 males between the ages of 4 and 33 years. The older subjects, i.e., those above 20 years of age, were students enrolled at a college of physical education in Stockholm and were reported to be in very good physical condition.

The results of a variety of physiological determinations under conditions of extreme work indicated that the mean maximum oxygen intake of adult males was 4.1 liters per minute as contrasted with 2.9 liters per minute in the case of adult females. Since there is generally a high correlation between body weight and maximum oxygen intake, similar comparisons were made with measures expressed in

terms of intake per Kg of body weight per minute. Again, however, the mean maximum oxygen intake of adult males was greater than that of the adult females (59 and 48 ml per Kg per min, respectively). Since the amount of hemoglobin seems to be the determining factor for oxygen intake, Astrand compared the men and women with respect to that and found no significant difference, suggesting that the obtained differences between the sexes in maximum intake cannot be attributed to differences in hemoglobin quantity.

The men and women in Astrand's study attained approximately identical values when compared with respect to anaerobic capacities (blood lactic acid concentrations); this indicates that the sexes are equal in their ability to use their physical resources--i.e., both men and women can strain themselves to equivalent states of exhaustion. This finding has been essentially confirmed in a Yugoslavian study of the productivity and fatigue of men and women in identical jobs (Petric, 1972). Specifically, no differences in either productivity or the reported experience of fatigue (rating scale and checklist) were found between 15 men and 47 women working as turners under identical conditions.

Men and women do differ with respect to the relative strengths of different muscle groups, and they may be expected to differ with regard to different basic capacities such as the four strength factors (static, explosive, dynamic, and trunk) that were discussed with Figure 2. Indeed, Laubach's (1976) analysis supports such findings; namely, women exhibit different ranges in strength abilities relative men, depending on the category of strength involved. For example, (a) in upper-extremity static strength, women range between 35% and 79% of the average for men, while (b) in lower-extremity static strength, the range was from 57% to 86%--obviously more akin to that of men. Likewise, (c) women's trunk strength (37% to 70% of men's) was, like upper-extremity static strength, relatively lower, whereas (d) their dynamic strength (59% to 85% of men's) was, like lower-extremity static strength, relatively higher.

In an ergonomic study designed to measure the maximum weights and workloads acceptable to women workers, Snook and Ciriello (1974) had 16 housewives and 15 women workers perform six different kinds of manual handling tasks--lifting, lowering, pushing, pulling, carrying, and walking. Comparison of the results with earlier studies of men showed that the men workers handled signficantly greater weight on the average than the women workers who, in turn, handled more than the housewives, particularly in lifting, lowering, and carrying. They conclude that "in most cases, one should be more selective in hiring a female for a manual handling task than in hiring a male," and while recognizing the desirability of meeting EEO goals, they point out that it is important "at the same time to recognize the differences that do exist, and to cope with these differences through adequate job design and selection procedures " (p. 533).

There are indications that women and men are similarly affected by physical-training programs in terms of improvements in physical conditioning or stamina. Specifically, Burke (1977) has recently reported a comparison of the physiological effects of aerobic training on untrained young-adult men and women. The experimental group was pre- and post-tested on a treadmill, and underwent an 8-week physical-conditioning program of running and walking between the two tests. The control group was tested over comparable intervals, but did not undergo the training. The results showed the expected improvements in the experimental subjects relative the controls--improvements attributable to the physical-training program.

Since the improvements in aerobic power were equivalent for the men and women, it can be concluded that where equivalent physical-training programs are employed with men and women, equivalent improvements in stamina (aerobic capacity) can be expected.

Summary and Conclusions

In the domain of physical performances, men appear to be superior to women in (a) simple reaction time, (b) gross motor responses to visually displayed information, (c) physical strength, (d) physical endurance under absolute-loading conditions, and (e) capacity for physical work.

On the other hand, women appear to be superior to men in (a) manual dexterity requiring fine coordination, especially (b) when responding to symbolic or semantic information.

The two sexes appear to be about equal in (a) physical endurance if loads are adjusted for differences in strength, (b) mechanical efficiency provided the work is adjusted for the differences in capacity, and (c) physical conditioning or trainability with equivalent training programs.

Given the trends towards more women participating in the workforce, over longer periods of time, and in a much broader range of jobs and worker classifications, reinforced in the United States by legislative, judicial, and executive actions that mandate equal employment opportunity for all persons regardless of sex, it is of increasing importance that jobs and tasks in the occupational environment be described in terms of dimensions representing their requirements for basic physical-performance abilities or capacities. A methodology that provides such descriptions, based on the nine physical-ability factors identified with factor-analytic procedures by Fleishman (1964), has been described. The method has been illustrated with data from an investigation of the physical-performance requirements of 15 benchmark jobs in a county-level governmental personnel classification system. The physical-ability requirement profiles of jobs produced by use of the proposed methodology, especially if extended with assessments of the importance of the different required abilities, should prove to be quite applicable, and valuable, in advancing selection and job-design procedures (cf. Snook & Ciriello, 1974).

Then, as has been suggested elsewhere (Alluisi, 1977), further advances may depend upon a reconceptualization of "jobs" as flexible combinations of tasks within a team or work-unit context that recognizes the possibility of between-worker trade-offs of tasks consonant with the differences in both task requirements and individual abilities. The advancement of these and other, as yet unconceived developments, are probably necessary to ensure further substantial progress towards a productively efficient, individually fair, legally just, and personally fulfilling utilization of an expanded workforce that truly provides equal employment opportunity for both women and men.

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